Characterization of the Optical Properties of Compositionally Graded Combinatorial Films

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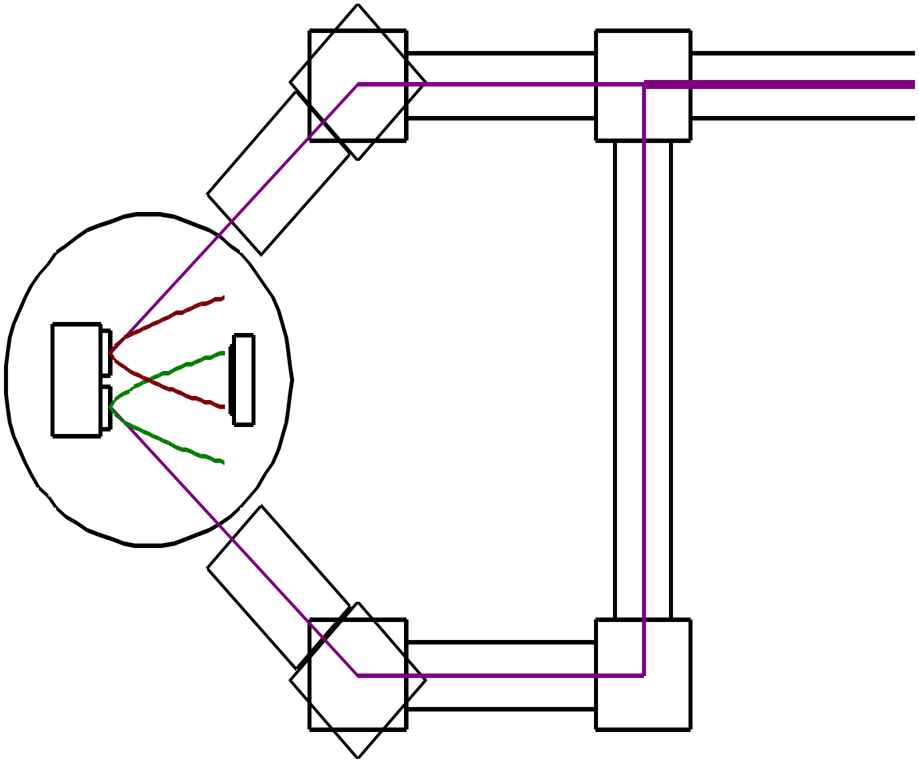
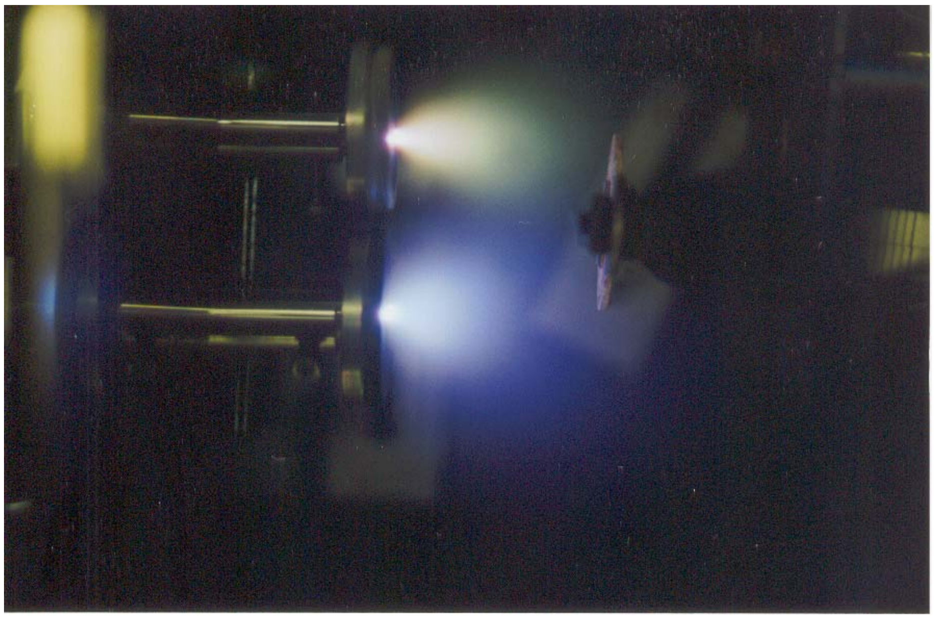
Dual Beam PLD for Combinatorial Films



- ***Dual Beam Delivery System***
  - **Independent adjustment of focus to control spot size on targets.**
  - **Adjustable beam dividing mirror aportions the laser energy to the two targets.**
- ***Deposition Chamber***
  - **Oil-less pumping and controllable buffer gas pressure.**
  - **Computer controlled heater.**
- ***Dual Target System***
  - **Targets rotate and raster in two dimensions relative to laser impact points.**
  - **Utilizes whole target and reduces particulates.**

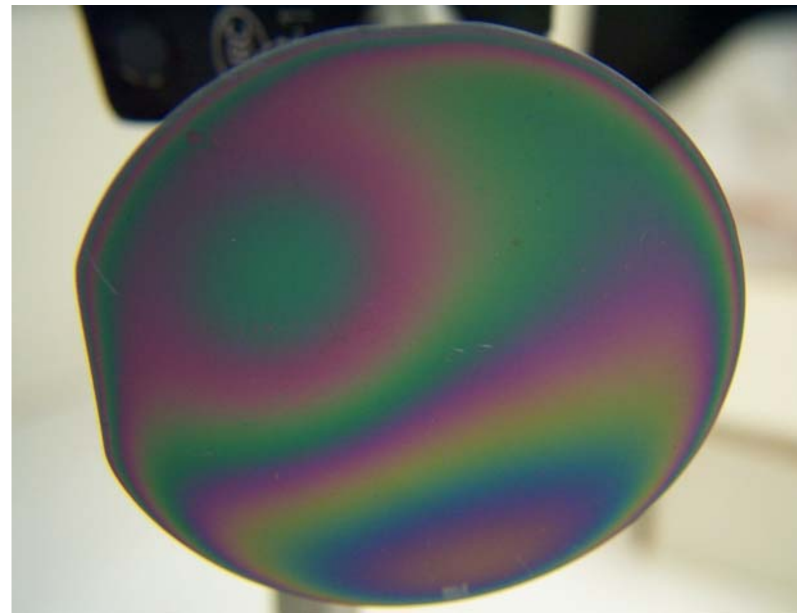
Compositionally Graded Combinatorial Films

Dual-Beam Dual-Target Pulsed Laser Deposition Production of Combinatorial Library Films



Target - heater distance 3 cm

$BaTiO_3$ - yellow $SrTiO_3$ - blue



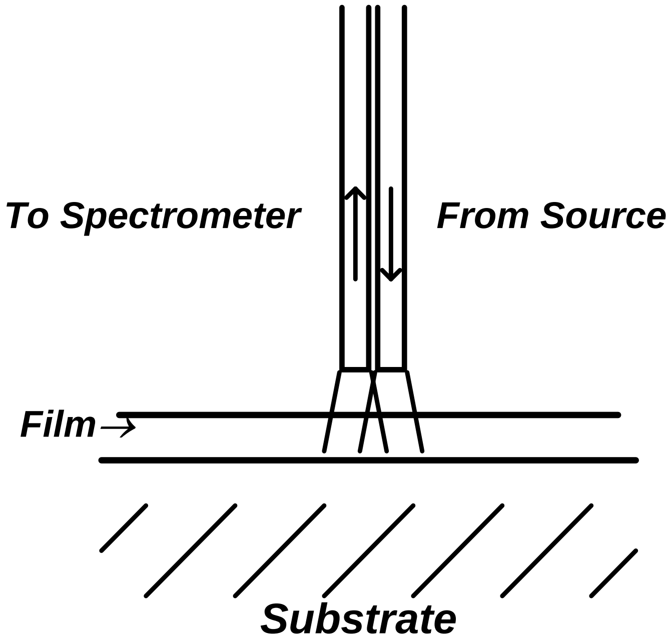
BT-ST library film

on a 2” (50.8 mm) Si wafer

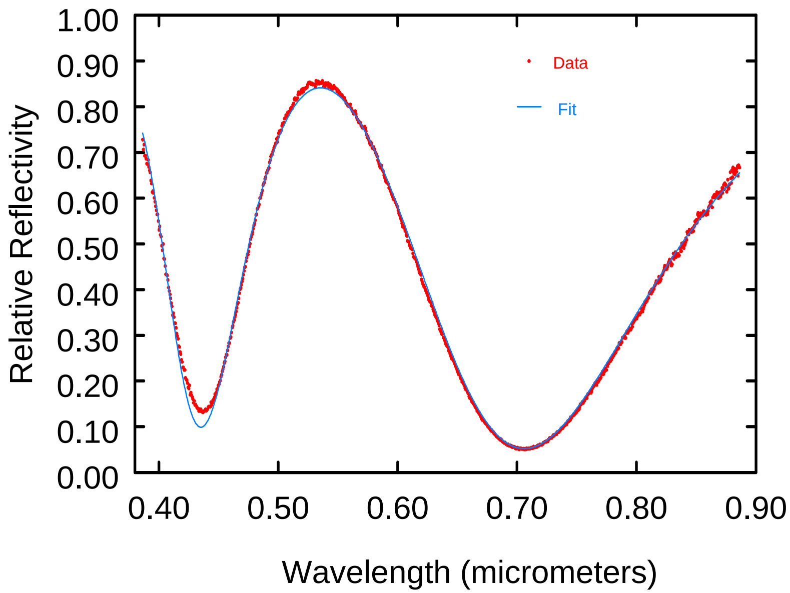
High Throughput Characterization of Film Thickness

Automated Spectroscopic Reflectometer

Bifurcated Fiber Optic Probe



Spectrum from 317 nm BST film



Substrate is mounted on a computer controlled XY stage (50 x 50 mm). Probe has spatial resolution of ~0.5 mm. Spectra are acquired in 1-2 seconds and fit in 3-4 seconds.

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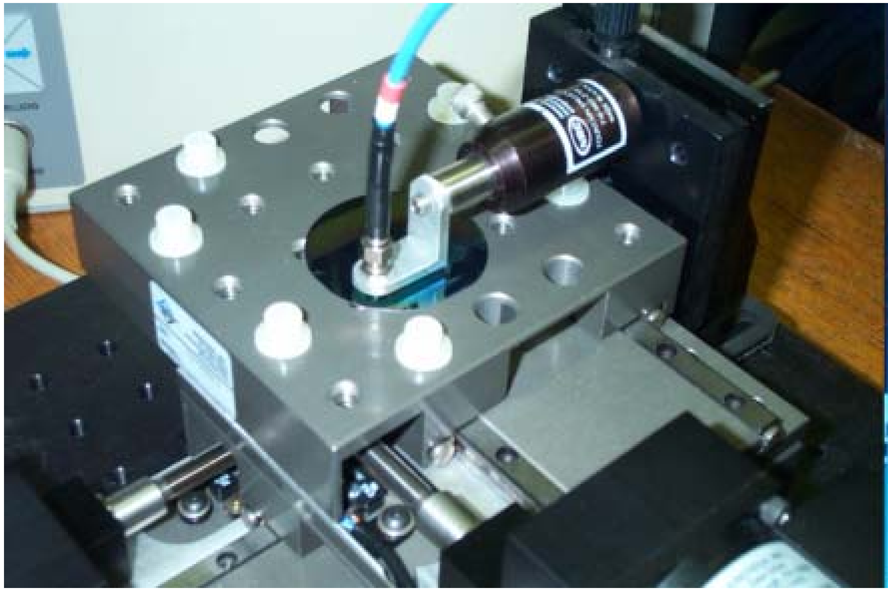
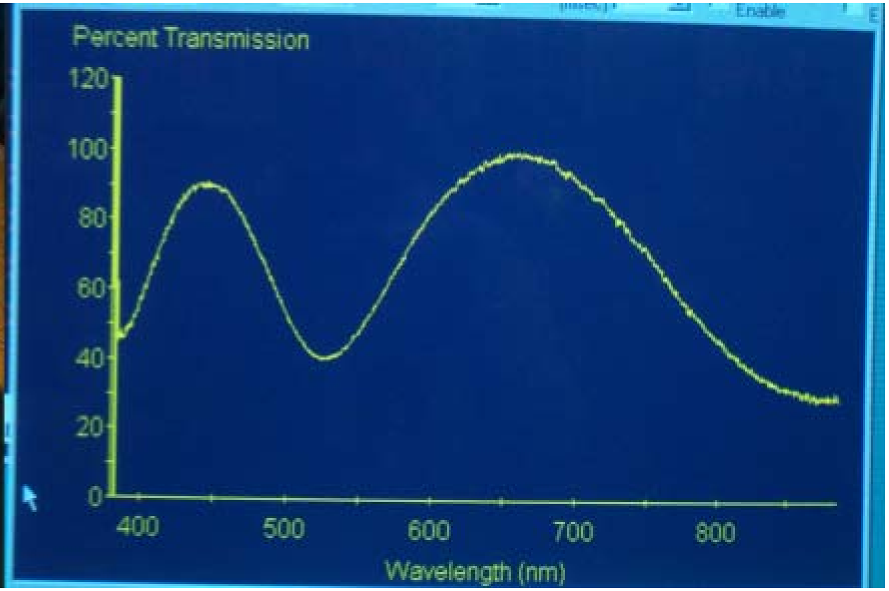
High Throughput Characterization of Film Thickness

Automated Spectroscopic Reflectometer





Semi-automated mapping of thickness: ~5 s/point

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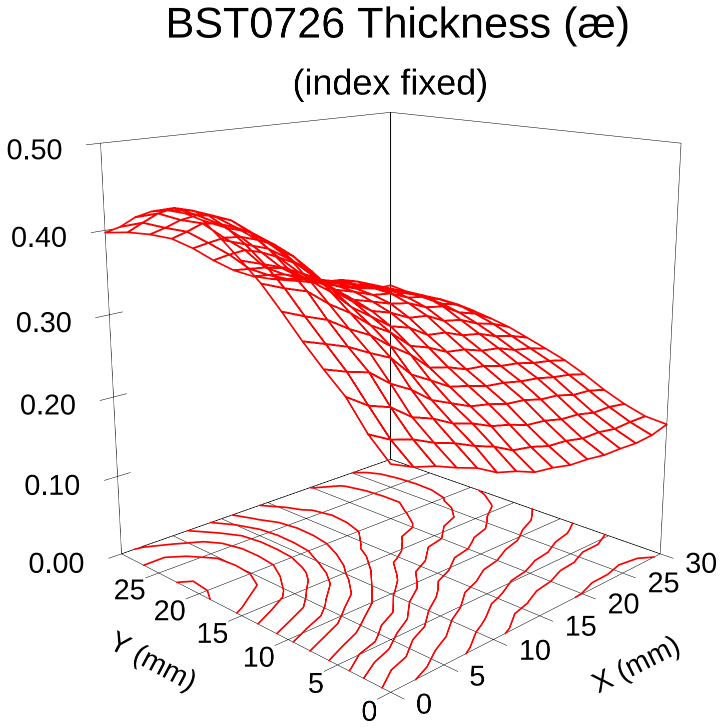
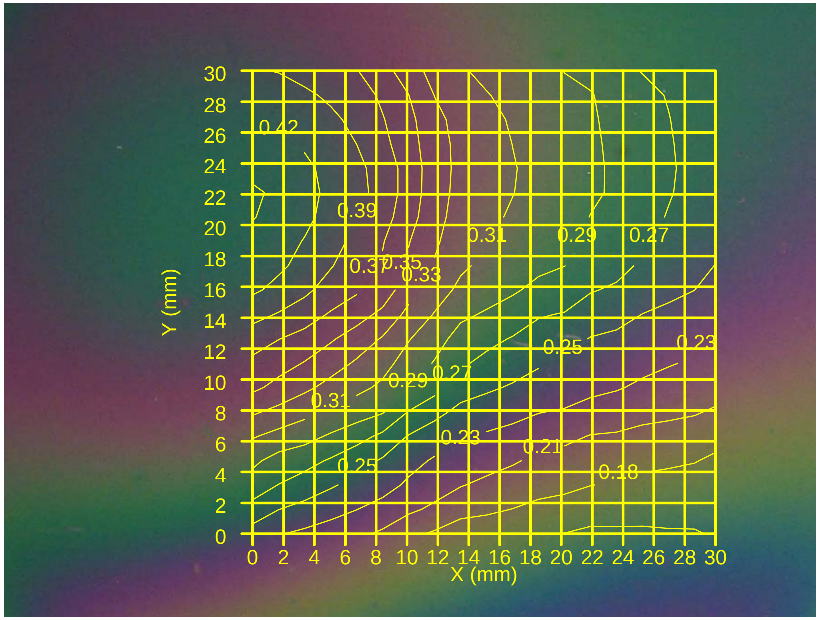
High Throughput Characterization of Film Thickness

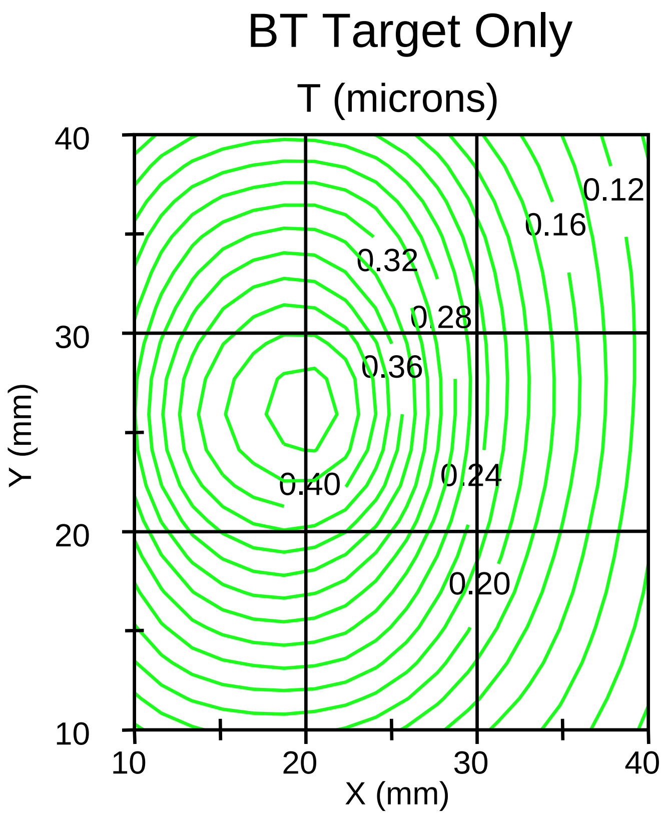
Two Dimensional Thickness Map of BST Combinatorial Library Film

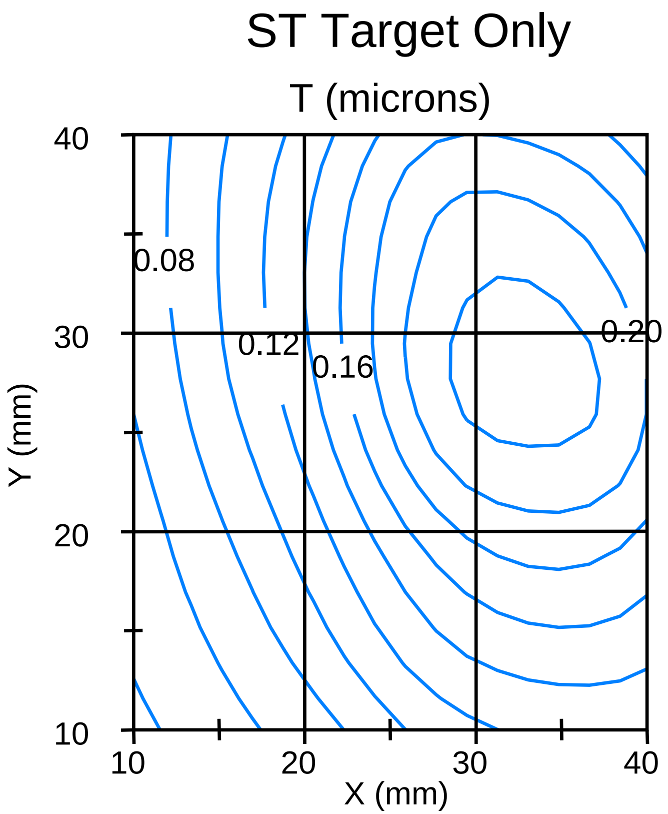




High Throughput Characterization of the Composition Gradient

Thickness maps are obtained from single target deposition patterns to calibrate the process.

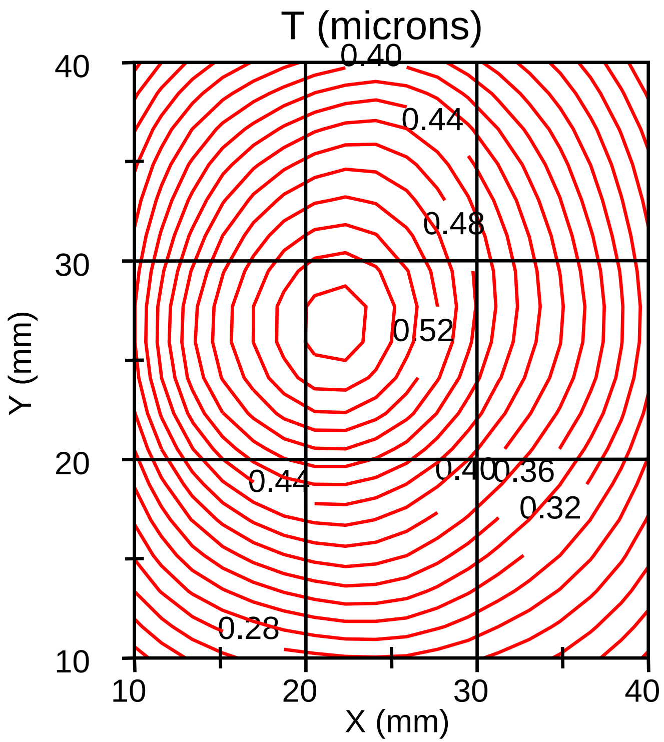




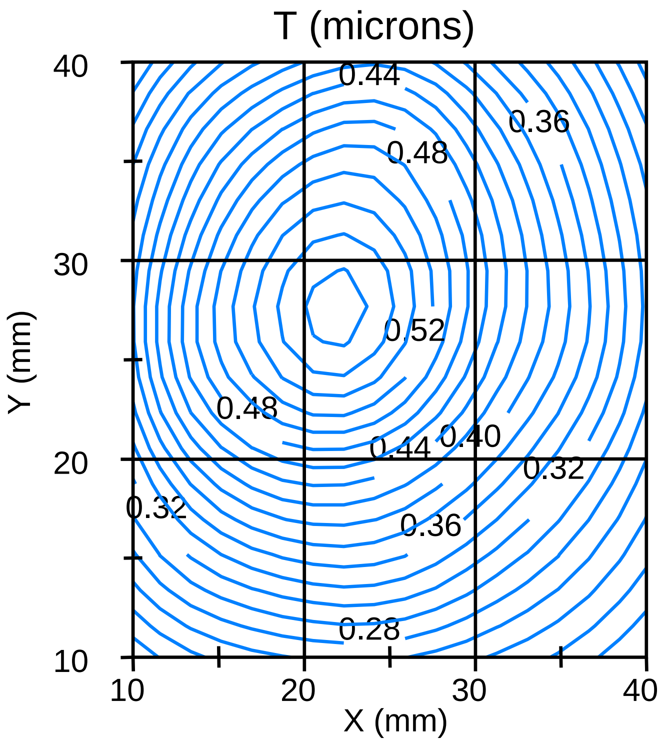
High Throughput Characterization of the Composition Gradient

The thickness map obtained by adding the thickness map from single target deposition patterns is nearly identical to the dual target deposition thickness map.

BT Only Added with ST Only



Both BT&ST Targets



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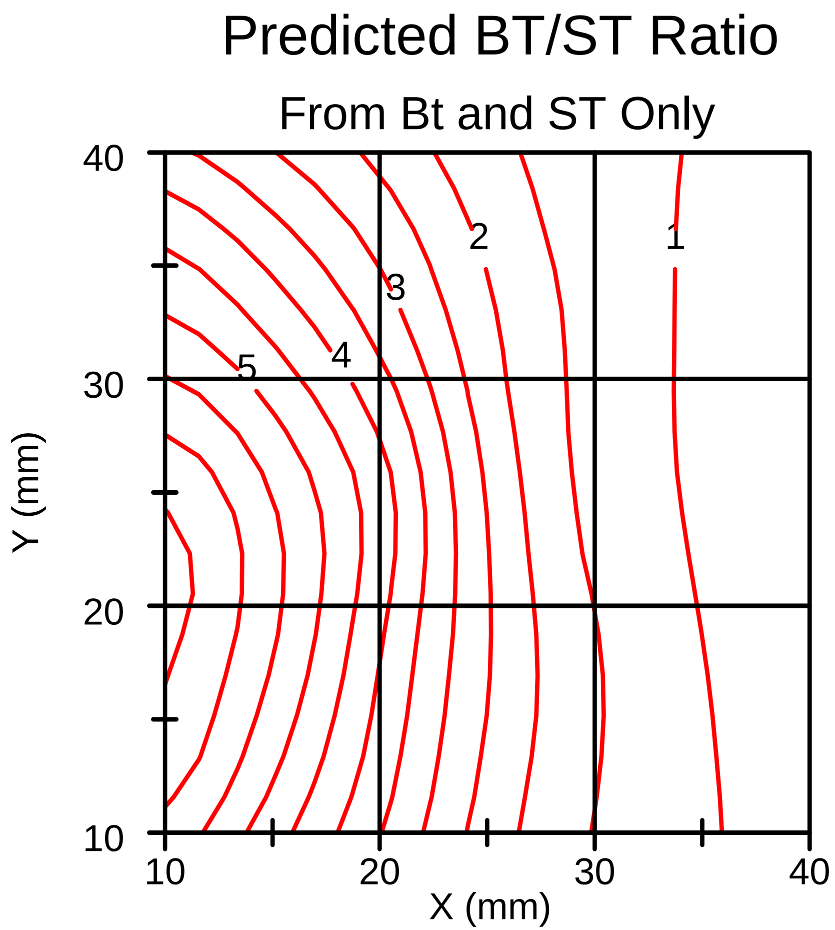
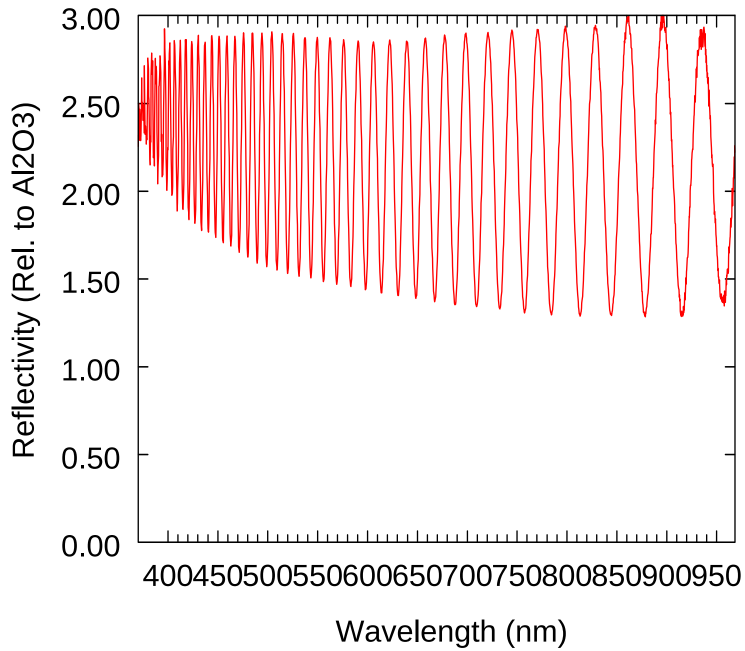
High Throughput Characterization of the Composition Gradient

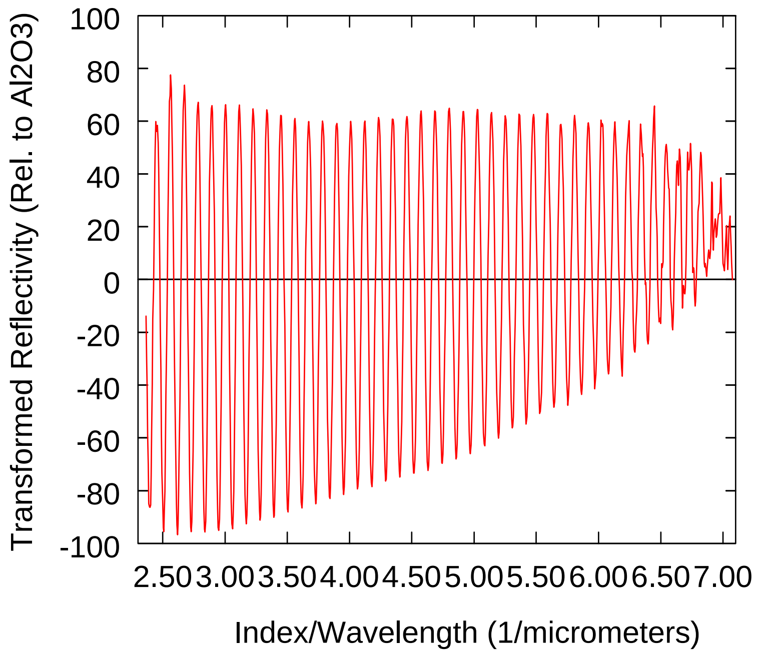


The composition ratio can be predicted with an accuracy as good as a direct measurement.

High Throughput Characterization of Thick Films GaN

Fourier Transform Spectroscopic Reflectometry: thickness mapping of GaN-on-sapphire film (prior to Au/Ni metal deposition)

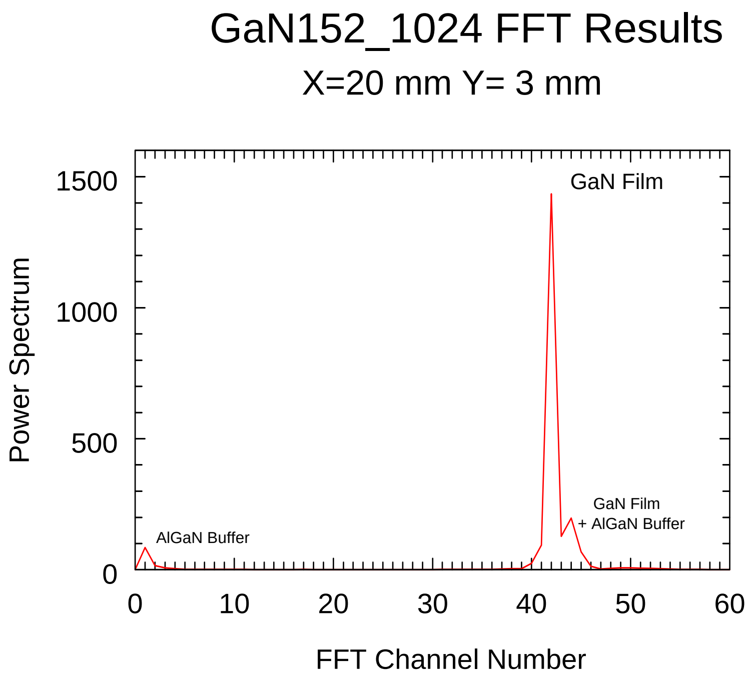


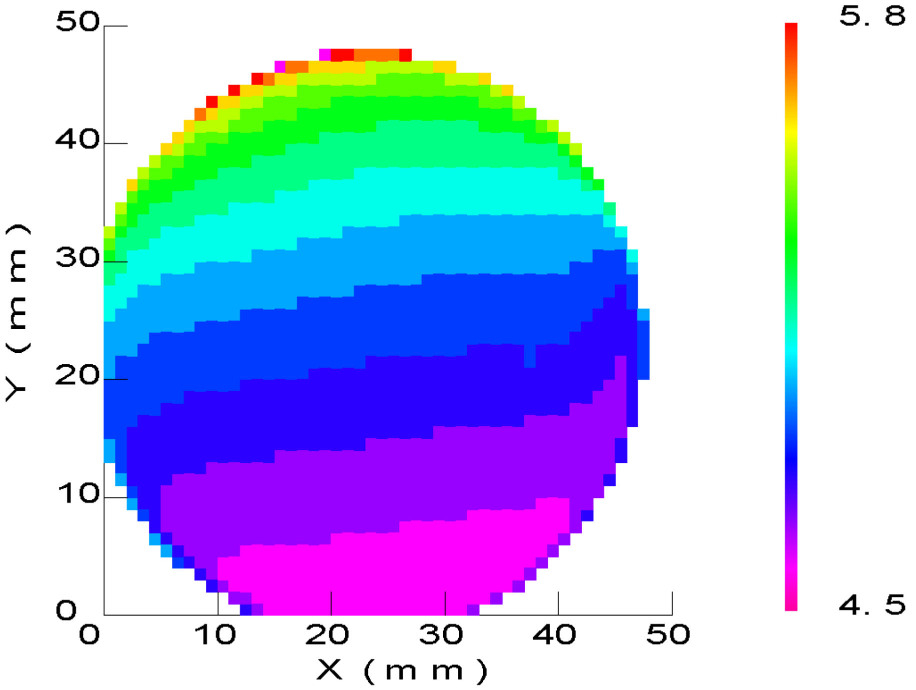


Convert wavelength data to equally spaced "energy" data ($n(\lambda)/\lambda$). $n(\lambda)$ data courtesy L. Robins, NIST.

High Throughput Characterization of Thick Films GaN

Perform FFT, each FFT channel is proportional to the thickness.





Thickness is 0.106 micrometers times the FFT channel number. The scale on the thickness map is micrometers.

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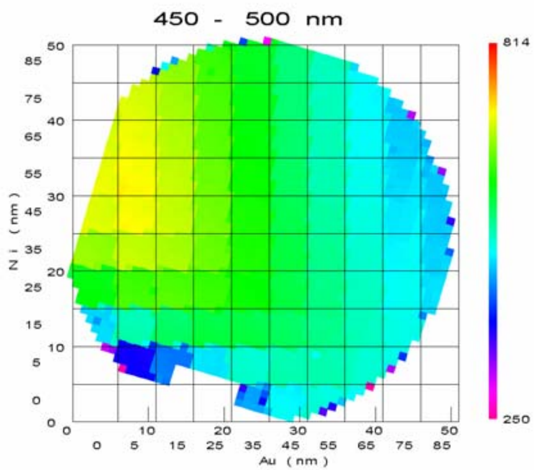
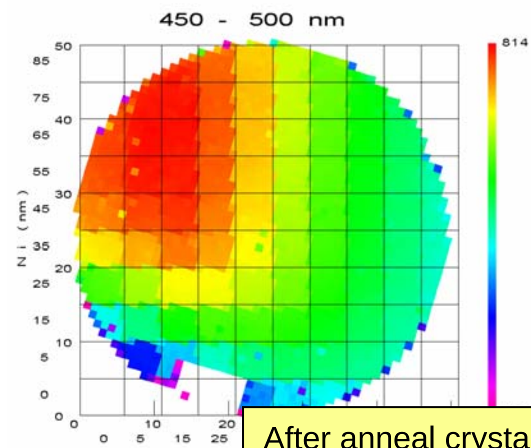
High Throughput Characterization of Au/Ni Contacts on GaN

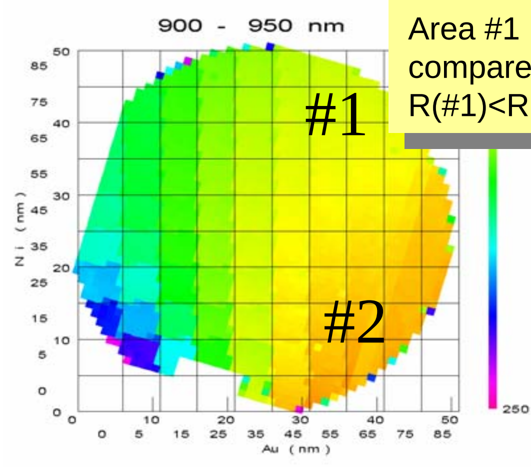


450-500 nm

400^{o}C/30s

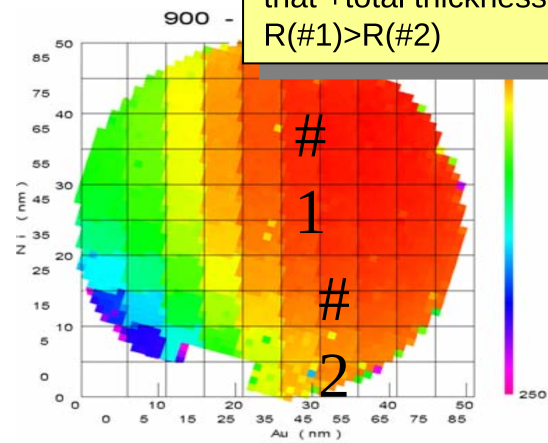


After anneal crystallinity improved (including that of area #1) => effect of that +total thickness effect caused R(#1)>R(#2)



Area #1 has poorer crystallinity compared to area #2 => R(#1)<R(#2)

900-950 nm

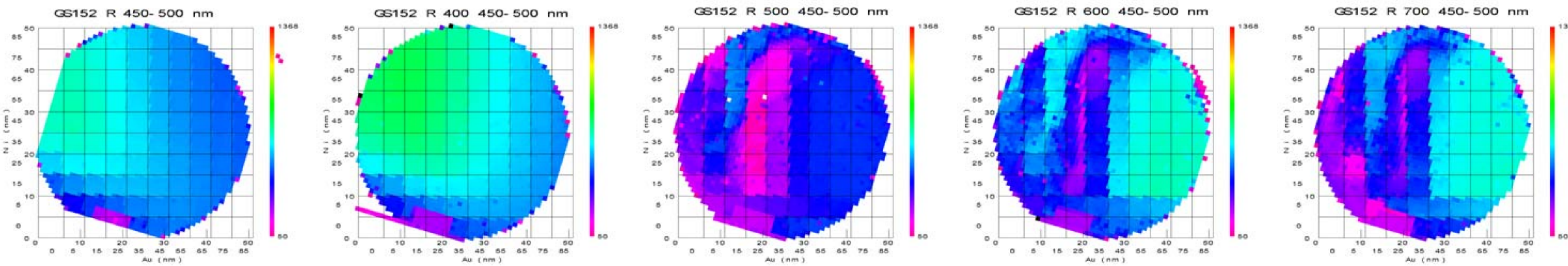


Reflectivity maps (relative to bare sapphire) before and after annealing (Albert Davydov, NIST).

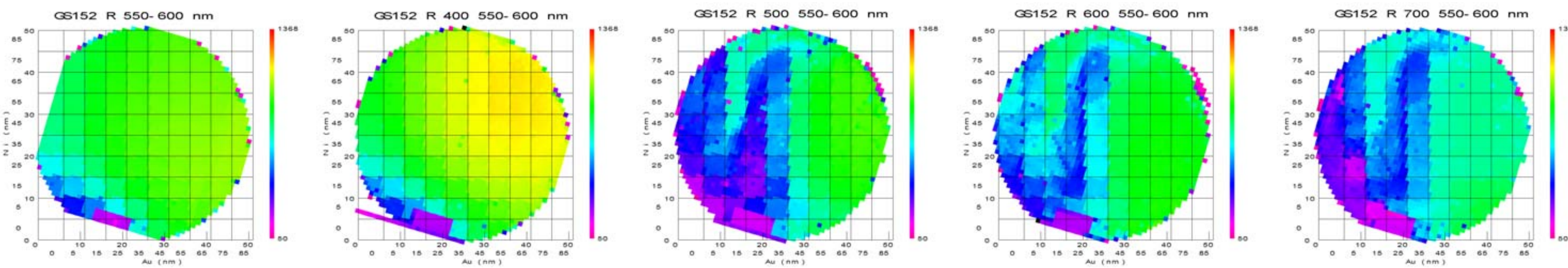
Reflectivity Maps of Au/Ni Contacts on GaN

As-Dep.	$400^{o}C$	$500^{o}C$	$600^{o}C$	$700^{o}C$

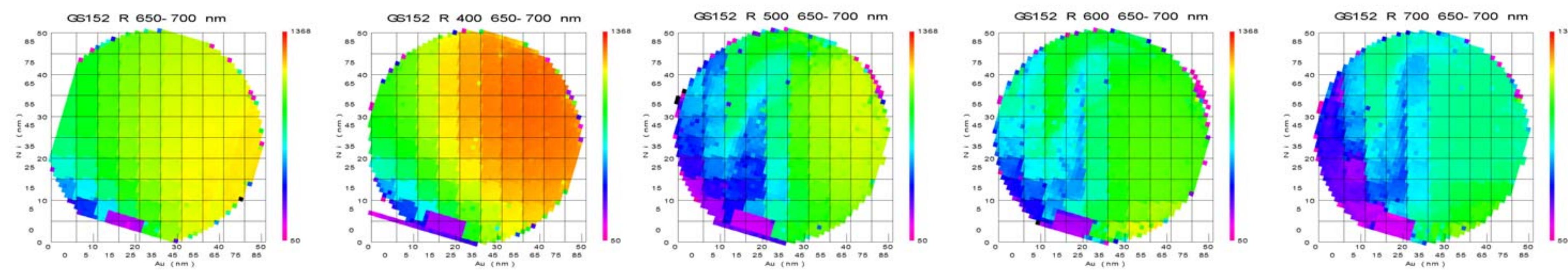
450-500nm



550-600nm



650-700nm



Summary and Conclusions

Automated spectroscopic reflectometry is a good high throughput characterization tool for measuring film thickness and index of refraction in compositionally varying combinatorial thin films.

Thickness maps of thin films produced with single target PLD depositions can be used to predict the thickness and composition of films produced with multiple target PLD depositions.

The metallization of wide-band-gap semiconductors can be characterized both in reflectivity and transmission by optical spectroscopy before and after processing. Both differences and changes in the crystallinity of the metal contacts can be mapped by these optical techniques and correlate well with parallel XRD measurements (Albert Davydov, NIST).